

# A Robust Approach for Multi-Modal Image Registration

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**ABSTRACT:** Image registration is the process of transforming the different sets of data into one coordinate system, which is required for comparing or integrating the data obtained from different measurements such as different viewpoints, different times, different imaging modalities etc. In medical imaging, multiple modalities of the same subject or organ provide complementary information that is very important for medical diagnosis and computer-aided surgery. In this work, a registration method based on extracting structural features by utilizing the complex phase and gradient-based information is proposed. This method has been tested on different modes.

**KEYWORDS:** Imageregistration, structural features, Multi-modal image registration.

## I. INTRODUCTION

Image registration is the process of overlaying two or more images of the same scene taken at different times, from different viewpoints, and/or by different sensors. It geometrically aligns two images into the same coordinate system so that the aligned images can be directly compared and analysed. Registration is widely used in remote sensing, medical imaging, computer vision etc.

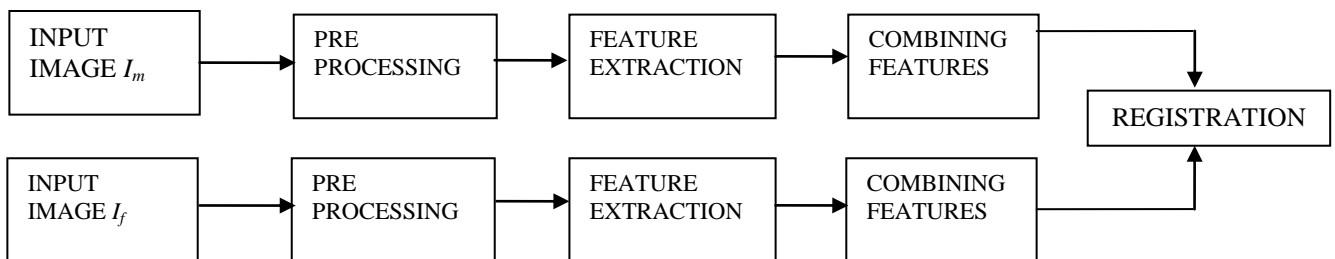


Fig. 1. Block diagram of the proposed method

Multi-modal image registration consists of combining images taken with different sensors which has wide applications in remote sensing and medical field. Medical image registration helps clinicians integrate the information obtained from different imaging modalities.

The objective of this method is to transform  $I_m$  and  $I_f$  to a new intensity mapping space using structural features [1]. In the proposed method, input images are pre-processed and then features are extracted from the pre-processed output. Bilateral filtering is used for pre-processing since it preserves edges. Features are extracted by applying phase congruency and gradient magnitude. Then these features are combined and registration is performed.

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(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

## II. PREVIOUS WORK

There are many algorithms existing for multi-modal image registration. Multi-modal image registration can be done using mutual information [2]. Here, registration corresponds to maximizing mutual information. Images have to be aligned in such a manner that amount of information they contain about each other is maximal. However it can be inferred that mutual information may not be an universal cure for all registration problems.

Conditional mutual information (cMI) has been proposed in [3], which requires more computation time. DeNigris et al [4] proposed a registration method based on the alignment of gradient orientations with minimal uncertainty. The combination of edge information and intensity information was utilized for registering images captured from different sensors, such as visible and IR images [5]. A multi-resolution approach was proposed in [6] by employing the dual-tree complex wavelet transform to align visible and infra-red images. Registering MR-CT images using complex phase order as a similarity measure is proposed in [7]. Also many methods based on wavelet transforms are proposed for image registration. In this paper, image alignment is achieved by the combination of phase information and gradient based features.

## III. PRE-PROCESSING

Image preprocessing is performed to improve the quality of images. If the images are too noisy or blurred (caused by instruments or patient's movement while scanning), they should be filtered and sharpened. In this paper, bilateral filtering is used for denoising.

The bilateral filtering is a technique of denoising while preserving edges. The bilateral filter is defined by

$$BF[I_p] = \frac{1}{W_p} \sum_{q \in s} G_{\sigma_s}(\|p - q\|) G_{\sigma_r}(|I_p - I_q|) I_q \quad (1)$$

Here  $W_p$  is the normalization factor that ensures pixel weights sum to 1.

$$W_p = \sum_{q \in s} G_{\sigma_s}(\|p - q\|) G_{\sigma_r}(|I_p - I_q|) \quad (2)$$

$I_p$  is the image value at pixel position  $p$ . Pixel size is assumed to be 1.  $F[I]$  designates the output of filter  $F$  applied to image  $I$ . Set  $s$  of all possible image locations that can be named as spatial domain and set  $r$  of all possible pixel values that is named as range domain.

## IV. FEATURE EXTRACTION

### 1. PHASE CONGRUENCY

The *Local Energy Model* postulates that features are perceived at points in an image where the Fourier components are maximally in phase as shown in fig. 2. Congruency of phase at any angle produces a clearly perceived feature.

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(An ISO 3297: 2007 Certified Organization)

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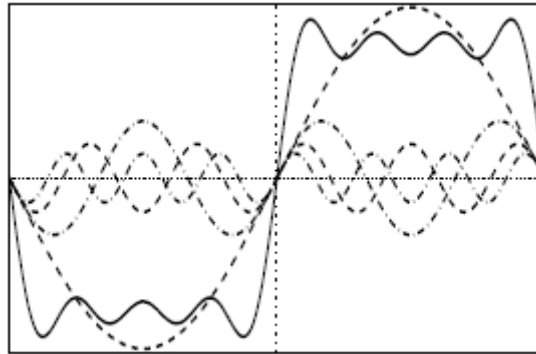


Fig. 2. Fourier series of a square wave and the sum of first four terms

The local, complex valued Fourier components at a location  $x$  in the signal will each have an amplitude  $A_n(x)$  and a phase angle  $\Phi_n(x)$ .

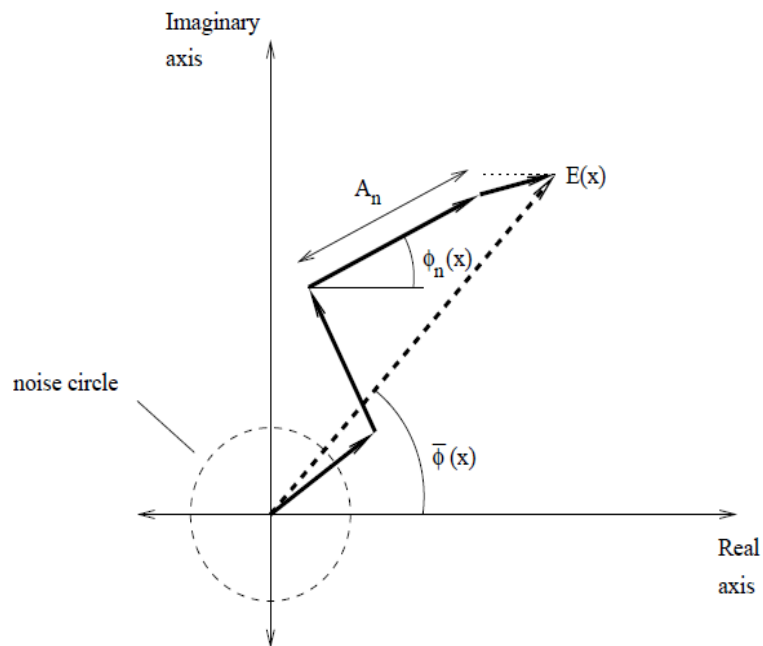


Fig. 3. Polar diagram showing the Fourier components at a location in the signal plotted head to tail.

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Fig.3 plots these local fourier components as complex vectors adding head to tail. The magnitude of the vector from the origin to the endpoint is the local energy  $|E(x)|$

$$PC(x) = \frac{|E(x)|}{\varepsilon + \sum_n A_n(x)} \quad (3)$$

Phase congruency is the ratio of  $|E(x)|$  to the overall path length taken by the local fourier components in reaching the end point. If all the fourier components are in phase, all the complex vectors would be aligned and the ratio of  $|E(x)|/\sum_n A_n(x)$  would be 1. If there is no coherence of phase the ratio falls to a minimum of 0. A small constant  $\varepsilon$  is added to avoid division by 0.

### 2. GRADIENT MAGNITUDE

Gradient of image is required to get the contrast information. In this paper, the common sobel operator is used to extract the gradient.

$$G_x(x) = \frac{1}{4} \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} * f(x) \quad (4)$$

$$G_y(x) = \frac{1}{4} \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * f(x) \quad (5)$$

Where  $G_x$  and  $G_y$  are the partial derivatives along the x and y directions. Then, the gradient magnitude is defined as

$$GM = \sqrt{G_x^2 + G_y^2} \quad (6)$$

### 3. COMBINING FEATURES

After feature extraction, next step is to combine features captured by complex phase with gradient based information. After applying intensity normalization on PC and GM, a combination strategy in the following form can be used

$$J(x) = g(f_1(PC(x))f_2(GM(x))) \quad (7)$$

where  $f_1$ ,  $f_2$ ,  $g$ , and  $J$  are respectively the function applied on the phase congruency, gradient magnitude of the image, fusing function, and the resulting image. The edge information obtained by gradient magnitude may be different in terms of contrast and brightness since images have different intensity mappings. Therefore, a step of intensity normalization followed by histogram equalization can help to equalize the edge representation [13]. The result of histogram equalization will be an image, named *IGM*.

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The goal is to fuse structures extracted by PC and edge information in such a way that pixel locations with high edge information will be strengthened in the PC image. Therefore, the combination strategy is proposed to be in the following format:

$$J(x) = I_{GM}^{\alpha}(x) \cdot PC^{\beta}(x) \quad (8)$$

where,  $0 \leq I_{GM}(x)$ ,  $PC(x) \leq 1$  and  $\alpha, \beta$  are constant parameters that are used to adjust the importance of phase congruency and edge information. The contribution of PC and GM in the resulting feature image can be controlled by adjusting factors  $\alpha$  and  $\beta$

Thus, (8) turns into

$$J(x) = \sqrt{I_{GM}(x)} \cdot PC(x) \quad (9)$$

Applying the above procedure on the input images,  $I_f$  and  $I_m$ , the resulting  $J_f$  and  $J_m$  will be images with the same intensity mapping that can be fed into a mono-modal registration procedure. Therefore, any intensity-based similarity/dissimilarity measure can be used in the optimization problem expressed in (1). In this paper, we use the sum of squares of intensity differences (SSD) as the dissimilarity measure which is defined as:

$$D(J_m, J_f) = \sum_n |T_n(J_m(n)) - J_f(n)|^2 \quad (10)$$

## V. EXPERIMENTAL RESULTS

Experiments were conducted on different MR modes. Here brain scans from three modalities, namely T1, T2 and PD are used. Fig.4 shows image denoising by applying bilateral filter. Fig.4(a) is the MR image corrupted by Gaussian noise and fig.4.(b) is the filtered output.

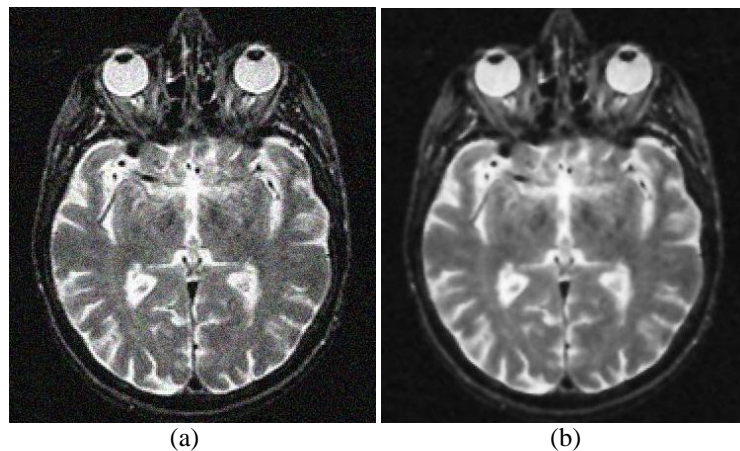


Fig. 4. Image denoising (a) MR image corrupted by Gaussian noise (b) Image filtered after applying bilateral filtering technique.

Figure.5 shows the structural features extracted from different modes. Fig.5(a,b,c) are the input images from different modes, namely PD, T1 and T2 respectively. Fig.5(d,e,,f) shows the structural features extracted from the three

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modes. Figure 6 shows the final registered images of PD and T2 modes. T2 mode is shown in green and PD mode is shown in red colour.

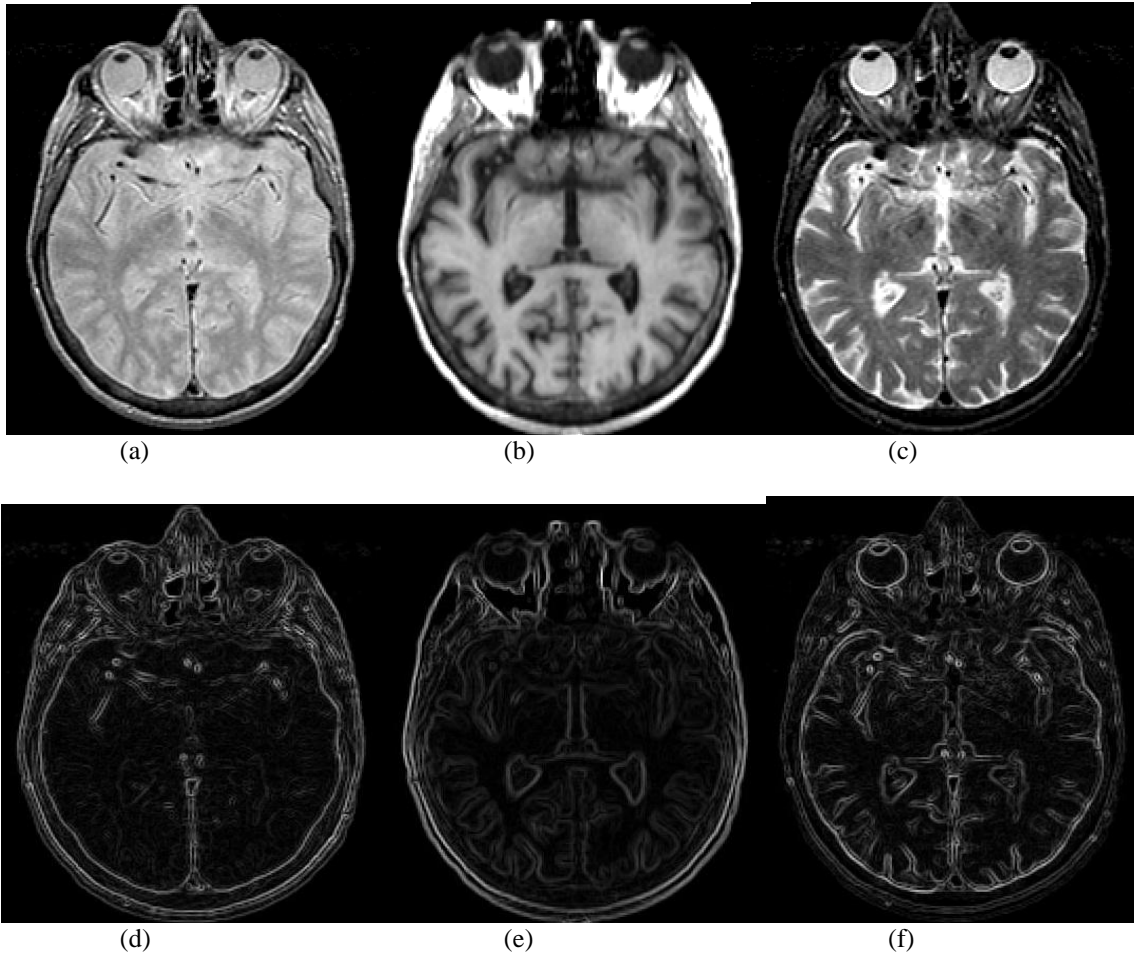


Fig. 5. Features extracted from different modes. The first row shows a slice of brain scans in PD, T1 and T2 modes. Second row shows the features associated with the first row images.

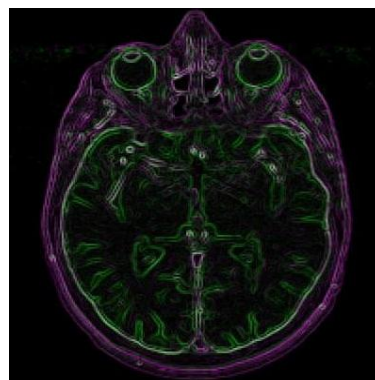


Fig. 6. Final registered image of PD and T2 modes. T2 mode (green) and PD mode (red)

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## VI. CONCLUSION

We have implemented a new method for registering multi-modal images using structural features. Most of the previous are based on statistical or structural similarity measure, which makes the procedure complicated. In this method, important features from the input images are extracted and further processing is done on these feature images. The feature extraction is by computing the phase congruency and gradient magnitude of the multi-modal images. Then the information captured by phase congruency and gradient magnitude is combined. Pre-processing is performed before feature extraction for getting better results. Experiments are conducted on different modes of images and results are analysed.

## REFERENCES

- [1] K. Kaisiri and P. Fieguth, "Multi-Modal Image Registration Using Structural Features" 36<sup>th</sup> Annual International Conference of the IEEE (5550-5553)
- [2] J. P. W. Pluim, J. B. A. Maintz, and M. A. Viergever, "Mutual information-based registration of medical images: a survey," *IEEE Trans. Med. Imag.*, vol. 22, no. 8, pp. 986–1004, 2003.
- [3] D. Loeckx, P. Slagmolen, F. Maes, D. Vandermeulen, and P. Suetens, "Nonrigid image registration using conditional mutual information," *IEEE Trans. Med. Imag.*, vol. 29, no. 1, pp. 19–29, 2010.
- [4] D. De Nigris, D. L. Collins, and T. Arbel, "Multi-modal image registration based on gradient orientations of minimal uncertainty," *IEEE Trans. Med. Imag.*, vol. 31, no. 12, pp. 2343–2354, 2012.
- [5] Y. S. Kim, J. H. Lee, and J. B. Ra, "Multi-sensor image registration based on intensity and edge orientation information," *Pattern Recognition*, vol. 41, no. 11, pp. 3356–3365, 2008.
- [6] M. Ghantous, S. Ghosh, and M. Bayoumi, "A multi-modal automatic image registration technique based on complex wavelets," in 16<sup>th</sup> IEEE Int. Conf. Image Process. (ICIP), 2009, pp. 173–176.
- [7] A. Wong, D. A. Clausi, and P. Fieguth, "CPOL: Complex phase order likelihood as a similarity measure for MR–CT registration," *Medical Image Anal.*, vol. 14, no. 1, pp. 50–57, 2010.